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*Technical Report*

# Tactical Command and Control Systems and Network Centric Warfare

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**Abstract-** One of the major requirements of a Command and Control (C2) system is to gather and distribute information. By bringing these systems under a network centric warfare architecture brings an integrated C2 system of systems. In this paper, information is given on current and near term air defence, fire support and battle management C2 systems. Capabilities for network centric warfare architecture are mentioned by applying of these capabilities to tactical C2 systems.

**Keywords-** Command and Control, Network Centric Warfare, Network Enabled Capability, Global Information Grid

## 1. Tactical Command and Control Systems

When we examine tactical command and control (C2) systems, we see that they basically send information gathered from various sensors and information sources to decision makers, which corresponds to tactical command centres in real life. After reviewing and analyzing this information, a course of action is decided and tasks are assigned to the relevant weapons and units accordingly. This cycle is typical for most C2 systems.

Tactical C2 systems can be classified according to their functional area, such as; Air Defence, Fire Support, Manoeuvre, Intelligence and Combat Support & Combat Service Support (Personnel and Logistics). Various C2 systems have been developed for these functional areas and are in use by the modern armies of the world.

Regarding the requirements of the Turkish Armed Forces, ASELSAN has developed and delivered functional areas as given below;

- Air Defence Systems
- Fire Support Systems
- Battlefield Management Systems

HERİKKS is the Air Defence C2 System, developed by ASELSAN and has been used by Turkish Armed Forces since 2001. The system is composed of an Air Defence Control and Coordination Centre at the Army Level and Corps and Brigade Level Air Defence Command and Control Centres operating at their respected levels. These Air Defence C2 centres have weapons and local and external sensors connected to them.

By using the sensor information received from local and external long range sensors, a combined and recognized air picture is formed and distributed to all relevant air defence units in at almost real time. Air picture is identified at Air Defence C2 Centres in coordination with the Air Force. Then, necessary course of action is taken by starting manual or automatic engagements to the appropriate weapon system. The engagement command is sent automatically to the weapon system. If the weapon is suitable, it is automatically cued to the related track.

A single integrated air picture (SIAP) is obtained through out the system by using sensor fusion algorithm. Low Level Air Picture Interface (LLAPI) is used to integrate with other allied country's air defence systems.

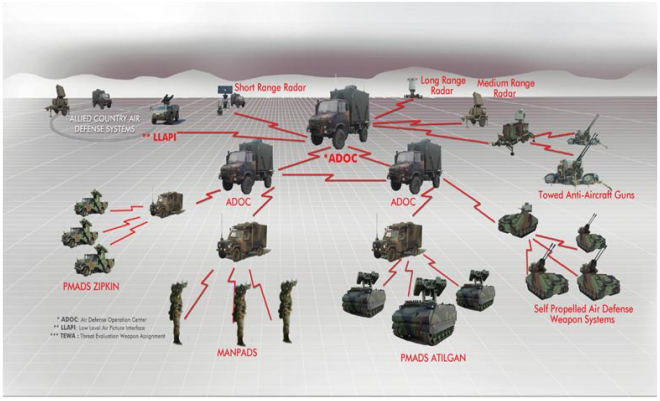


**Fig. 1.** HERİKKS

The system is also integrated with Turkish Land Forces Command Tactical Area C2 System and Air Forces Information System.

HERİKKS has been used by Turkish Naval Forces since 2008 for harbour air defence. The main difference between two applications is that the Naval version has C2 centre in a fixed site. In December 2008, ASELSAN was awarded a contract for HERİKKS, Phase 3, which was delivered and fielded in 2012. Work is in progress for the next HERİKKS upgrade, to be delivered in 2017-2018. It will include integration of new air defence weapon and sensor systems.

In the Fire Support functional area, ASELSAN has developed and delivered Tactical Fire Control System and Fire Support Automation System which is in use by Turkish Army since 2005.The system has units interconnected at corps, brigade, regiment and battalion levels. The system has a C2 centre at Corps Tactical Operation Centre – Fire Support Element. The target acquisition systems (Forward Observers, Fire Support Teams) provide target information to their Tactical Operation Centres. At the command centre, most suitable weapon for the designated target is calculated and fire mission is sent to this weapon system. The system makes ballistic calculations for the selected weapon system based on the selected ammunition and current weather conditions. The weapons are cued to the target accordingly.

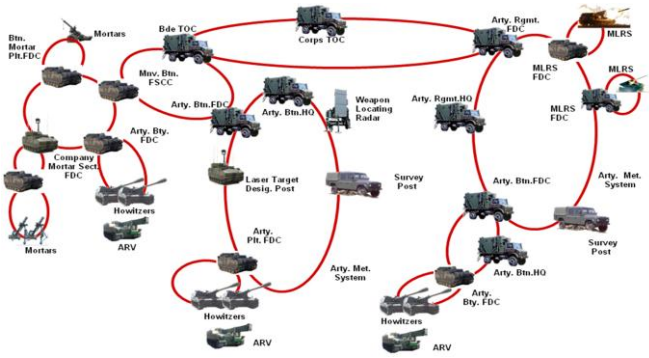


**Fig. 2.** Fire Support Automation System

For Battle Management, ASELSAN has developed Battle Management and Unit Tracking System (BATUR). BATUR is a C2 system that provides operational planning, situational awareness, common tactical picture, decision aids and functionalities to support the preparation with the mission supporting analysis tools, execution and after mission phases of operation for the contact units, multiplying the effectiveness of the maneuvers.

BATUR is designed to be fielded on mounted and dismounted maneuver forces including armored, mechanized infantry and infantry battalions, their combat support, combat service support, surveillance and reconnaissance units. BATUR provides seamless battle command. It increases the operational capabilities of the maneuver units from battalion level to the single platform/soldier level.

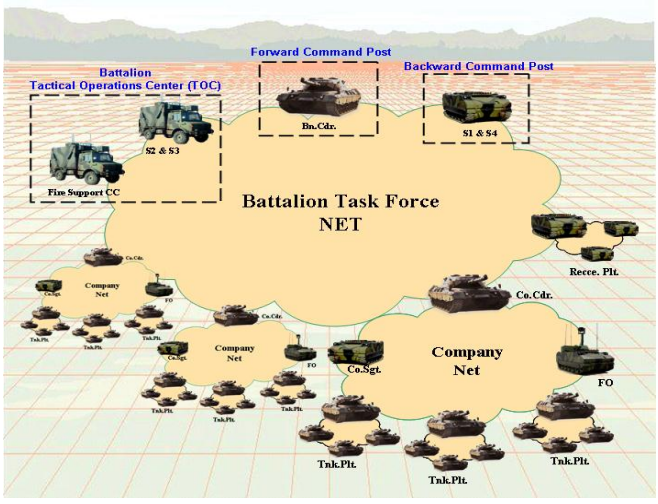


**Fig. 3.** ASELSAN BATUR



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Another Tactical C2 system within the intelligence domain is the C2 of Electronic Warfare (EW) systems. Coordination between the electronic support measure (ESM) systems and electronic counter measure (ECM) systems is very critical in an EW operation. The signal intelligence (SIGINT) obtained from ESM systems (Communications Intelligence (COMINT) and Electronic Intelligence (ELINT)) are used by ECM systems to plan a successful electronic attack (EA) to the opponent systems.

Under C2 architecture, the ESM systems gather intelligence about the location and formation (Electronic Order of Battle (EOB)) of the enemy units, which is very valuable information for other friendly C2 systems around the area.

## 2. C2 Systems Common Capabilities and Simulation Capabilities

When we examine Air Defence, Fire Support and Battle Management Systems, C2 systems have common functions. These systems basically provide tools and services to increase situational awareness and help in decision making process. These tools and services are typically GIS capabilities, analysis functions, reporting capabilities, user authorization and authentication services and integrations with other C2 systems.

Depending on its characteristics and purpose, C2 systems can be mounted on sheltered vehicles, tanks, fixed sites or on a man worn system. These systems are also typically interconnected to the on board systems, such as fire control systems, vehicle systems, positioning systems.

**Fig. 4.** Shelter Mounted C2 System

The other important capability of C2 systems is the decision support algorithm. In a rapidly changing environment, it is critical to support the decision makers by analysing the situation and making recommendations about the course of action.

For Air Defence systems, Threat Evaluation and Weapon Assignment Algorithm (TEWA) is used for this purpose. The algorithm dynamically evaluates the current air picture, by taking into consideration parameters such as; type and location of available weapons and targets, effect of these weapons on these targets, status of the weapons. This function is very critical especially in a complex environment when there are lots of targets which cannot be handled manually. The system can make automatic engagements if necessary, or make recommendations for an engagement to a target.

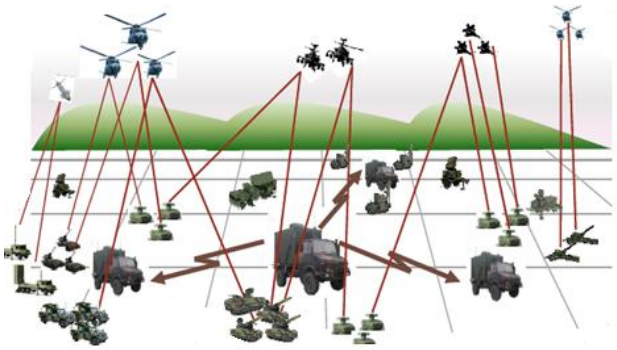

**Fig. 5.** Decision Support

A similar algorithm is also used in Fire Support systems. In a fire mission, a target list is formed with targets planned to be hit with a desired effect, or on call targets are analysed. The fire support decision algorithm analyses the fire mission and calculates the most suitable weapon system that will be effective on this target. In order to obtain the desired effect, munitions effectiveness algorithm calculates how many rounds should be fired on the target. After making ballistic calculations for that target, fire order is sent to the corresponding weapon.

After the deployment phase of the system, simulation capabilities are also critical both during the development phase and for training

System Effectiveness Analysis Laboratory (SEAL) is a current project that ASELSAN has invested on its establishment, in order to monitor efficiency of Air Defence Systems developed by ASELSAN. SEAL is aimed to be used for analyzing the effectiveness and determining possible improvements of these systems being produced by ASELSAN.

SEAL will serve as a simulation framework for distributed simulations along with its modeling and analysis capabilities.

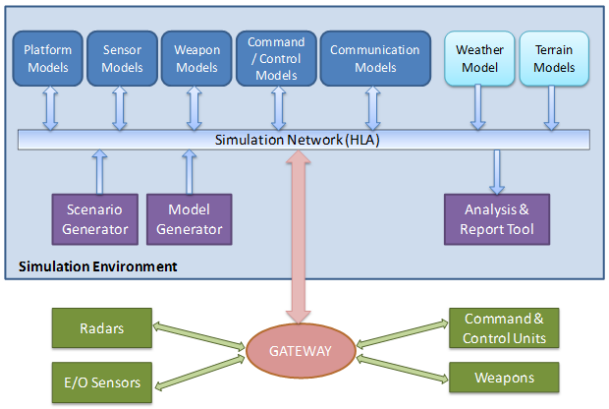


**Fig. 6.** SEAL Architecture

Another simulation infrastructure is the ASELSAN TEWA Analysis & Evaluation Tool (aselTAT) that is used to test a TEWA Algorithm with various scenarios and make interoperability tests for two GBAD systems running different TEWA Algorithms.

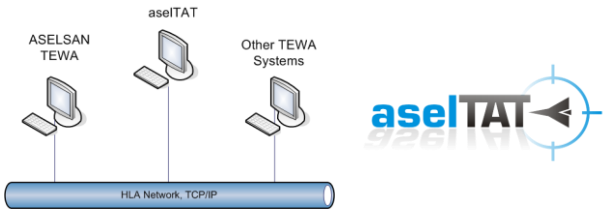


**Fig. 7.** aselTAT Architecture

The scenario generator provides a standard interface to the algorithms over an HLA network. It is possible to configure test architecture to test a single algorithm or two different algorithms that can either cooperate or operate independently.

## 3. Short Term C2 Systems

When we look at the systems that are going to be in service within five years, the following systems will be integrated under HERİKKS architecture:

- Low Altitude Air Defence Missile System (LALADMIS)
- Medium Altitude Air Defence Missile System (MALADMIS)
- 35mm Self Propelled Air Defence Gun System
- Fire Control Centre

HERİKKS is the overarching architecture (system of systems) for these Ground Based Air Defence (GBAD) systems.

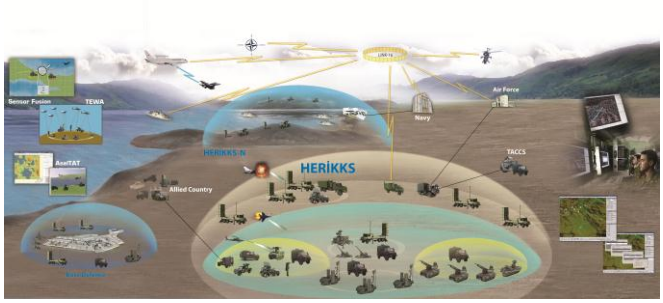


**Fig. 8.** Integrated Air Defence

Under the HERİKKS umbrella, GBAD systems with various capabilities starting from very low altitude up to medium altitude will be interconnected with interfaces to both Air Force assets and NATO systems, building up an integrated air defence system of systems. Link-16 tactical data link capability will be accomplished within the MALADMIS project, which will be the major communication infrastructure with other C2 systems.

Another system that is being developed as an R&D project is the soldier battle management C2 system. Depending on the configuration and mission requirements, following equipment could be mounted on the soldier for various C2 applications:

- Portable radio for voice and data communication
- Portable computer
- GPS



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- Arm Display Unit
- Weapon Mounted IFF interrogator
- Various sensors to monitor health status, ammunition status, acoustic fire direction calculation
- Battery and solar charging panel
- Network module to interconnect the sensors and computer

By using acoustic sensors, soldiers can identify shooter direction when they are being fired. Using such sensors increase the situational awareness both for the soldier and other friendly units as the information is being shared. Soldier BMS C2 systems have applications related to all major functional domains, such as Air Defence, Fire Support, Intelligence. Some typical applications are Manpads units in Air Defence Systems, forward observers in Fire Support Systems, sniper detection systems for infantry units.


**Fig. 9.** Soldier BMS

## 4. Network Centric Warfare

Under the network centric warfare architecture (NCW), it is vital that these C2 systems operate in a synchronized manner. Within this architecture, a fire support system can receive target information from an Intelligence System, combat service support units could monitor the logistic status of the units and resupply in a short time, friendly unit and enemy unit locations can be shared among all friendly forces which could all be defined as a force multiplier for modern armies of the world.

Aselsan is working on establishing an integrated C2 system of systems.

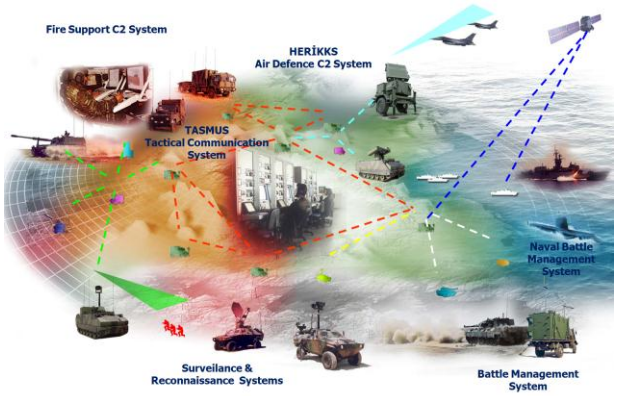


**Fig. 10.** Integrated Battle C2 Systems

The C2 systems work together as a single system, usually referred to as "systems of systems".(DoD, 2001). Systems of systems is defined as different mission specific systems come together and combine their resources and capabilities to form a more complicated system that has more functional capabilities and performance.

Today, system of systems approach is used not only in defence industry, but also in civil sectors such as transportation, health, space research. Integrating the domain specific C2 systems under a system of systems architecture enables a more effective C2 system. Communication systems supporting the network centric warfare architecture and services supporting the information exchange between C2 systems is vital for a successful C2 system. US Department of Defence (DoD) define these communication infrastructures and services as Global Information Grid (GIG).

Among the major capabilities of NCW is the ability to access information at any time and any location by all the present and future units in every echelon and share this information for faster and better decision making process.

It is criticized that the current C2 systems are ineffective in this manner. It is mentioned that the information exchange is done at specific nodes depending on the nature of the C2 systems and as more and more interfaces are available within those systems, it makes these systems more complicated and hard to manage. (Zenishek & Usechak, 2005) It is also mentioned that current systems do not support a dynamic architecture for new users and new systems that will be integrated,

therefore new interfaces and new integration processes have to be implemented. (DoD, 2007)

By taking into consideration the objectives of Network Centric Warfare and experience from the C2 applications, NATO and US DoD foresee that the future data exchange technology for the applications in the battlefield should be based on Service Oriented Architectures (SOA). (DoD, 2007; Lund, 2007)

SOA is widely used in web based civil internet applications. It could be defined as a distributed architecture where separate software services built up a functional capability. In SOA, there are service/information providers, service/information users, and the interaction between these two parties form the bases of the SOA. One of the main advantages of SOA is that the services built up a functional capability of a system can run independently. This way, the user applications do not need to know where to request a service from beforehand, and the service provider applications can provide services to more than one user simultaneously. (ADatP-34, 2005)

NATO Interoperability Standards and Profiles (NISP, 2013), developed by the NATO Consultation, Command and Control (C3) Board, includes interoperability standards and profiles which are mandatory for use in NATO common funded Communications and Information Systems (CIS) to support C3 interoperability by assisting in the transition to the NATO Network Enabled Capability (NNEC). The standard points out short term and midterm standards. Emerging technologies are fading and become mandatory for a NNEC system. It is mentioned that information technology is undergoing a fundamental shift from platform-oriented computing to network-oriented computing. This shift from platform to network is what enables the more flexible and more dynamic network-oriented operation.

NATO SAS-085 study group made research on C2 requirements for 21st century military operations. The study points out that the military missions are large and complex, with extreme uncertainty and spectrum of challenges such as counter-insurgency, counter-terrorism, stabilization, reconstruction and support to multi-agency disaster relief. These missions are referred to as Complex Endeavours and require the participation and contributions of a large variety of military and non-military actors, a collective that SAS-085 refers to as a Complex Enterprise. The study points out that one of the key requirements for a C2 system is Agility. SAS-085 has developed a conceptual model of C2 Agility that captures the relevant variables and relationships. (Alberts et al., 2010) The study results of this group have been published as NATO NEC C2 Maturity Model (N2C2M2). (Mitchell et al, 2010).

Although SOA brings a lot of capabilities to NCW, there are also some drawbacks to this architecture. Applications are very much dependent on the services provided by other applications, which in turn brings development costs and processing power costs for the applications.(Perera, 2006; Zenishek & Usechak, 2005). In order to use SOA on mobile platforms, SOA messages need to be compressed. (Lund et al, 2007; Hafsøe et al, 2007) The applications also need to be optimized by taking the communication capabilities in the tactical field into consideration.

Despite these studies, using SOA effectively in the forward end tactical units is in very much related to the improvements on the communication capabilities of these units.(Lund, 2007) Looking at the current available technology, it is believed that in the short term, it will not be effective to use SOA for these units. One of the areas where SOA can be used effectively in tactical field is Tactical Command Posts and Headquarters. (Bieger, 2003; Ackerman, 2005) Command Centres at Brigade and upper levels usually have higher communication bandwidths which is an important infrastructure for using SOA services.

## 5. Conclusion

One of the main requirements of a C2 system is to acquire and distribute information. By bringing such systems in the tactical field forms an integrated C2 system of systems. These systems form an information sharing infrastructure based on NCW architecture. There have been many studies ongoing since NCW concept has been outlined. Some of these studies have been carried out under NATO study groups, of which their

results have been published as reference models or standards. Using SOA on mobile platforms over tactical communication networks is currently being studied.

In the short term, it seems that using SOA at units above brigade level is more effective due to the availability of a higher bandwidth. The situational awareness for C2 systems will be increased in accordance with technology, starting from the single soldier up to the higher echelon command centres.

## References

Ackerman, R.K. (2005). Defense Knowledge Management Hinges On Compatibility. Signal.

Alberts, D. S., Huber, R. K., & Moffat, J. (2010). NATO NEC C2 Maturity Model. Office of The Assistant Secretary of Defense, Washington Dc Command And Control Research Program (CCRP).

Allied Data Publication 34 (ADatP-34) (2005). NATO C3 Technical Architecture Volume 2 Architectural Descriptions and Models. Version 7.0.

Bieger, G. and Carpenter, J. (2003). Openwings A Service-Oriented Component Architecture for Self-Forming,Self-Healing, Network-Centric Systems. www.openwings.org/ download/ specs/ openwingswp.pdf

DoD (2001). Department of Defense Report to Congress, Network Centric Warfare, July 2001.

DoD CIO (2007). Department of Defense Global Information Grid Architectural Vision. Vision for a Net-Centric, Service-Oriented DoD Enterprise.

Hafsøe, T., Johnsen, F. T., Lund, K., & Eggen, A. (2007, June). Adapting Web services for limited bandwidth tactical networks. In 12th International Command and Control Research and Technology Symposium (ICCRTS), Newport, RI, USA.

Lund, K., Eggen, A., Hadzic, D., Hafsoe, T., & Johnsen, F. T. (2007). Using web services to realize service oriented architecture in military communication networks. Communications Magazine, IEEE, 45(10), 47-53.

Mitchell, D. W., Alberts, D. S., Bernier, F., Farrell, P. S., Pearce, P., Belanger, M & Henshaw, M. (2014). C2 Agility. NATO Research &Technology Organisation.

NATO Interoperability Standards and Profiles (NISP, 2013). Allied Data Publication 34(G).

Perera, D. (2006). Netcentric In a Snap The goal of netcentric warfare is to enable troops to adapt on the fly, but that means technology has to become plug-and-play. Government Executive-Washington Dc-, 38(9), 48.

Zenishek, S., & Usechak, D. (2005). Net Centric Warfare and Its Impact on System of Systems. Defense Acquisition Review Journal, 12, 217-232.